Wide Area Power System Damping Controls with Network Communication Delays

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Introduction

• In this poster we propose a new mathematical method to estimate the maximum allowed communication delay that does not violate the stability and performance of the power system.

• This method allows us to handle continuous and discrete dynamics as two pieces of the same framework, such that the system will switches between a continuous-time subsystem (when the communication occurs without any interruption) and a discrete-time subsystem (when the communication fails) by introducing time scales theory.

Method

• Time scales

\[ \mu(t_2) = \sigma(t_2) - t_2 \]

\[ \tau(t_1) = t_2 - \sigma(t_1) \]

1. Receiving perfect information and controller is evolving

\[ \tau(t_i) = t_{i+1} - \sigma(t_i) \]

2. Not receiving perfect information (delay) and controller is hold on

\[ \mu(t_i) = \sigma(t_i) - t_i \]

• Switched system

\[ x^A(t) = \begin{cases} (A + BK)x(t), & t \in \bigcup_{i \in \mathbb{N}}[\sigma(t_i), t_{i+1}] \\ \left( e^{(A+B)k} - I \right)(I + A^{-1}BK)x(t), & t \in \bigcup_{i \in \mathbb{N}}[t_{i+1}] \end{cases} \]

• Stability Criteria

\[ \| e^{(A+B)\tau(t_i)} \left( I + \left( e^{A(t_i)} - I \right)(I + A^{-1}BK) \right) \| < 1 \]

Case study

• Case 1: For \( \tau = 0.2s \)

• Case 2: For \( \tau = 0.5s \)

Conclusion

A stability criteria has been derived to estimate bounds of the communication loss duration, which guarantees the stability of the system.

Future work

• Test stability criteria in larger system with considering communication failure.